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(54) Method and apparatus for electrophotographic printing.

(57) In a conventional electrophotographic printing machine, a cleaning device which has been used to remove residual toner is eliminated by using a toner and a carrier each having a spherical configuration so as to cause a cleaning operation and a developing operation to proceed simultaneously at the developing unit. With this printing machine not only the construction of the machine can be simplified but also an extremely fine toner can be efficiently used.

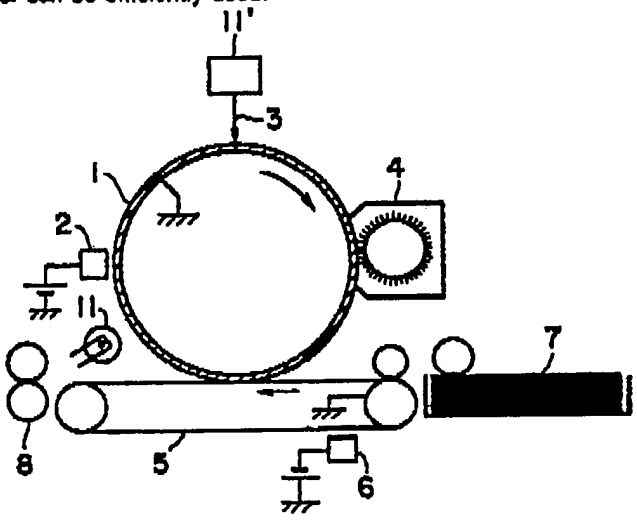

FIG. 1

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METHOD AND APPARATUS FOR ELECTROPHOTOGRAPHIC PRINTING

BACKGROUND OF THE INVENTION

This invention relates to a method and apparatus for electrophotographic printing, more particularly an electrophotographic printing not requiring use of a cleaning device.

In a prior art electrophotographic copying machine it was essential to use a cleaning device that cleans or wipes off a toner remaining on the surface of a photoconductive member after transfer printing a toner image. Cleaning of the remaining or residual toner had an importance of higher than 20% of the entire step of an electrophotographic printing machine. Prior art cleaning devices include use of a brush or a blade and a so-called two revolution device in which the polarity of a bias voltage applied to a developing device is reversed at an interval of two revolutions for effecting cleaning. It has long been desired to eliminate such cleaning device and method so as to simplify the construction and operation of the electrophotographic printing machine, but no effective method and device have been available.

Although Japanese Laid Open Patent Specification No. 133179/1988 discloses an electrophotographic printing machine not using a cleaning device, this Laid Open Patent Specification does not teach the subject matter recited in the appending claims.

SUMMARY OF THE INVENTION

It is an object of this invention to provide a novel method and apparatus for electrophotographic printing which are not necessary to use cleaning device.

Another object of this invention is to provide a novel method and apparatus for electrophotographic printing wherein the developing operation and the cleaning operation proceed simultaneously without using a conventional cleaning device.

A still other object of this invention is to provide a novel method and apparatus for electrophotographic printing capable of using a toner having an extremely small diameter that cannot be used satisfactory.

According to one aspect of this invention there is provided an electrostatic printing method for use in an electrophotographic copying machine comprising a photosensitive member, a charging unit for charging the surface of the photosensitive member, a light image projecting unit for forming a latent image on the surface of the photosensitive member, a developing unit for developing a latent image by utilizing a dry type toner and a dry type carrier, a transfer printing unit for transfer printing a developed latent image onto a copying sheet, and a light projecting unit for projecting light onto the surface of the photoconductive member to erase hysteresis thereof, a charge polarity of the toner being the same as that of the charging unit, characterized in that the method comprises the step of using a toner and a carrier both having spherical configurations so as to cause a developing operation and a cleaning operation to proceed simultaneously at the developing unit.

According to another aspect of this invention there is provided an electrophotographic printing machine comprising a photosensitive member, a charging unit for charging the surface of the photosensitive member, a light image projecting unit for forming a latent image on the surface of the photosensitive member, a developing unit for developing the latent image by utilizing a dry type toner and a dry type carrier, a transfer printing unit for transfer printing a developed latent image onto a copying sheet, and a light projecting unit for projecting light onto the surface of the photoconductive member for erasing hysteresis thereof, the charge polarity of the toner being the same as that of the charging unit, characterized in that both of the toner and the carrier have spherical configurations so as to cause a developing operation and a cleaning operation proceed simultaneously at the developing unit.

BRIEF DESCRIPTION OF THE DRAWING

In the accompanying drawing:

Fig. 1 ia a diagrammatic sectional view showing the electrophotographic printer embodying the invention; and

Fig. 2 is an enlarged sectional view showing a transfer belt utilized in the printer shown in Fig. 1.

DESCRIPTION OF THE PREFERRED EMBODIMENT

I have thoroughly investigated the operation of an electrophotographic print r, more particularly the operation of a developing device and found that where spherical dry type toner and carrier are used the cleaning device at the developing device can

be eliminated.

Firstly, I have found that the printer of this invention and the prior art printer are based on different theories. More particularly, where Se is used to prepare a photosensitive member of an electrophotographic copying machine, the surface of the photosensitive member is charged with a positive charge which is discharged by bright portions of a projected light image. A powder toner does not adhere to such discharged portions. By utilizing this fact so-called positive visualizing or developing method has been utilized in which a negatively charged toner is used. On the other hand, in a printer so-called negative developing method has been used by utilizing the fact that electric charge applied onto the portions of the photosensitive member which are irradiated with a light image discharges so as to decrease the surface charge and that the toner is caused to adhere to such discharged portions.

It has not been well understood the fact that the performance of the toner differs greatly in these two methods so that these methods have not been used practically.

I have noted the following facts. More particularly, in the case of a printer utilizing a positive type photosensitive member, the surface thereof is applied with positive charge, the charge at portions of the photosensitive member illuminated by a light image is discharged and a latent image at portions, the charge thereof has been discharged, is visualized by a positively charged toner. This cycle of operation is repeated. In this case, even when a positively charged toner is subjected to a negative corona discharge during transfer printing, the toner would be finally charged positively. In other words, at the time of entering the next operating cycle, the remaining toner has a tendency of having the originally charged polarity. This fact is important.

Where a positive development is effected as in a copying machine, at the time of entering the next cycle the remaining toner would be charged to a polarity opposite to that inherently applied. For the reason described above, in the next cycle a mixture of toners having opposite polarities would exist and the toners flocculate to form particular lumps, thus not only losing the inherent performance of the toner but also dislocating the mechanism of an electrostatic system.

Another problem to be solved lies in that the residual toner hinders the light image projection of the next operating cycle.

It is said that the efficiency of transfer printing is generally 70 to 80%. This low transfer printing efficiency can be increased by improving the toner. However, even when the residual toner exists, car should be taken that the optical effect of the projected light image would not be impaired. In a printer, the average particle diameter of the toner is smaller by on order of magnitude than the diameter of the projected optical dots so that even when a residual toner of 20 to 30% exists, 70 to 80% of the surface of the photosensitive member would receive uniform light projection which is sufficiently large light exposure quantity.

Actually, however, the quality of the picture image is greatly influenced by the characteristic of the toner used. It is a third important feature of this invention to determine the characteristic of the toner.

In the method of this invention characterized by not using a cleaning device, it is necessary to remove the residual toner produced at the time of transfer printing in the previous operating cycle, at the same time as the development. To this end, it is necessary that the surface area of the developing agent, especially a carrier, is sufficiently large and that the developing agent can readily roll at the time of development. This is the second important feature of this invention.

In this invention, suitable selection of the material and system that satisfy the conditions described above is essential to realize the method and apparatus of this invention characterized by not using a cleaning device.

To realize the method and apparatus of this invention characterized by not using a cleaning device, the following conditions must be satisfied.

(1) Different from a copying machine, in a printer effecting negative development, it is a recent tendency to eliminate a cleaning device,but mere use of prior art materials and method is not sufficient.

(2) The developing device and the developing agent should have smooth movement and a high fluidity so that cleaning and development can be performed simultaneously.

(3) The toner should have as far as possible high efficiency of transfer printing and it is desirable that even a residual toner may exist its optical shielding effect is small.

(4) A case wherein the toner is charged with an opposite polarity should be avoided.

Conditions (1) - (4) are arranged in accordance with their degree of importance.

The detail of this invention will be described with reference to the accompanying drawing.

Embodiment 1

I have used substantially th same printer as a commercially availabl laser beam printer employing a Se type photos nsitive member. The diameter of a photosensitive drum was 80 mm and the process sp d was 114 mm/sec. This embodim nt

is characterized in that a residual toner cleaning device is not used. I have improved the direction of rotation and the number of revolutions of a developer, and the surface of a magnet roller such that the developing agent used adheres most smoothly to a developing surface and that the developing agent can roll over the developing surface. Furthermore, in accordance with this invention, the operating timing of a transfer printing corona discharge device was adjusted such that while a copying paper is not being sent the transfer printing corona discharge device would not operate.

As a developing agent was used a carrier manufactured by Tetsugensha Co., Japan. The carrier comprised by spherical iron powder having a mean particle diameter of 60 μ , the surface of each spherical iron powder being magnetized.

As a toner was used a spherical toner having a mean particle diameter of 7 μ manufactured by Nippon Paint Co., Japan, the surface of each toner being covered by a polarizable high molecular weight substance.

Other conditions were the same as the operating conditions of a prior art printer.

It was found that even though the cleaning device was omitted, perfect print out without any hysteresis was continuously obtained. Whether the print out is effected continuously or intermittently or when the relative humidity was varied in a range of from 20% to 80% or when the ambient temperature was varied in a range of from 0° C to 30° C, perfect printing without any hysteresis could be stably made.

The characteristics of the developing agent utilized in the embodiment 1 is characterized by the method of manufacturing the developing agent. With regard to the carrier, the iron powder consists essentially of a spherical iron powder produced by a carbon eliminating step of the iron manufacturing steps. The surface of the iron powder is heat treated in a nitrogen atmosphere or covered by an anion resin. The iron powder is characterized in that each powder has a substantially perfect spherical configuration and that the iron powder consists of nearly 100% iron. Of course, the surface of each powder should be extremely smooth. The toner is also spherical. Each toner comprises a spherical core obtained by polymerizing an organic substance containing a coloring agent, and uniformly covered by a cation resin of a small quantity.

The fact that both carrier and toner are spherical enables the developing agent to exhibit extremely uniform characteristics as well as an extremely satisfactory fluidity. Spherical configuration means the widest actual moving area. Moreover both carrier and toner are spherical irrespective of a state of admixture of the toner and carrier so that it is possible to establish a stable charged state.

It has been said that with a spherical toner, cleaning of the residual toner is difficult. For example, as disclosed in Japanese Laid Open Patent Specification No. 501040/1988 the surface of the spherical toner is intentionally made irregular for increasing the cleaning efficiency. In my invention no such measure is taken. More particularly, the toner can be charged uniformly and the particle diameter of the toner is substantially uniform: for example 7 μ ± 1 μ. Substantially 100% of the surface of each toner particle is covered by a cation resin. The surface of the carrier is also homogeneous and smooth. The reason that the characteristics of the toner were carefully selected lies in that there is no toner charged to the opposite polarity. Should toner particles charged to the opposite polarity present, the toner would accumulate using the toner particles as nuclei, thus forming lumps. In a case wherein toner particles having extremely different diameters are used the same disadvantageous phenomenon occurs, thereby not only decreasing resolution but also resulting in a nonuniform transfer printing. If one tries to improve the mean transfer printing efficiency, lumps described above result in poor transfer printing. The residual toner not only prevents formation of high quality optical images, but also prevents cleaning which is effected at the same time as the development.

An unstable toner produced by crushing has such defects as a poor fluidity, a large particle diameter and a nonuniform charging caused by insufficient dispersion of a charge control agent (CCA).

It should be understood that the carrier is not limited to an iron powder used in Embodiment 1. For example, a ferrite type carrier can also be used.

The effect of using a spherical toner and a spherical carrier can be evaluated from another aspect. Spherical carriers having a mean particle diameter of 30 μ or 20 μ can readily be prepared. Also spherical toners having a mean particle diameter of 30 μ or 1 μ can readily be prepared because the spherical toners are manufactured by a polymerization method. In the method of this application, when an adequate charge relation holds between the carrier and toner, the particle diameter of the toner does not present any problem. Accordingly, where an extremely fine toner having a mean particle diameter of 1 μ, for example, is used and where the carrier particle diameter is selected to 20 μ corresponding to the small mean diameter of the toner, the advantage of eliminating the cleaning device can be obtained. As a consequence, there is the advantage that toners having an extremely small mean particle diameter, such as 1 μ, and which have not been able to be

used in the past because of the difficulty of handling, can now be used practically, to realize a picture image having high resolution.

As above described, the negative polarity corona discharge applied at the time of transfer printing has a negative effect upon the method and apparatus of this invention. A method and construction for eliminating the negative effect will be discussed in the following embodiment 2.

Embodiment 2

Referring now to Fig. 1, an electrophotographic printer of this invention comprises a rotary drum 1 made of metal and carrying a photosensitive member, a corona discharge device 2 for applying a positive or negative charge onto the photosensitive member, means 11 for projecting an input light signal 3, a developing device 4, a transfer belt 5 for transferring a copying paper 7 to a transfer printing station at the contact position between rotary drum 1 and transfer belt 5, a corona discharge device 6 for charging the surface of transfer belt 5, a developer 8 for developing a toner image transfer printed onto the copying paper 7 and a light source 11 for erasing hysteresis of the photosensitive member, all the elements described above being disposed about the periphery of the photosensitive drum 1 in a manner well known in the art.

Fig. 2 shows a cross-sectional view of the transfer belt 5 which comprises a lining 9 made of electroconductive rubber and a flexible insulating thin layer 10. The construction of embodiment 2 is different from that of embodiment 1 in that a transfer printing system shown by reference numerals as 5 and 6 is added.

The surface of the flexible insulating thin layer 10 is charged to a polarity opposite to that of the toner, by the corona discharge device 6 shown in Fig. 1. The degree of charging is such that the surface potential of the insulating thin layer 10 would be about 2000 V, for example.

The thickness of the flexible insulating thin layer 10 is generally of the order of from 20 μ to 70 μ. The operating principle of the transfer printing system shown in Fig. 1 is greatly different from the prior art transfer printing system in that according to this invention the toner is transferred to the copying paper from the surface of the photosensitive member by an electric field created by the charge presenting on the surface of the transfer belt, whereas according to the prior art transfer printing system the corona discharge is applied to the rear surface of the copying paper.. More particularly, the transfer printing effect by the transfer belt is static so that there is no fear of injecting an excessiv charge into the ton r caused by the bombardment of the corona discharge. Further, since the transfer belt is constructed to be homogeneous and smooth, the electric field created by the charge on the surface of the transfer belt extends vertically to the belt surface and has a uniform intensity at all points. As a consequence, the residual toner remaining after the transfer printing can be reduced greatly. Since the decrease in the quantity of injection of the charge of the opposite polarity into the toner presenting on the surface of the photosensitive surface is not influenced by the presence or absence of a copying paper, in the embodiment 2 the charging of the transfer belt surface can be effected continuously irrespective of the feeding of copying paper without causing any trouble.

Elements other than the transfer printing system are identical to those used in the embodiment 1.

Embodiment 2 shows that it is useless to charge the toner presenting on the surface of the photosensitive member to an opposite polarity with reverse polarity corona discharge. Since a system is required in which ions at the transfer printing member would not be directly bombarded by the opposite polarity corona discharge, the invention is not limited to the transfer belt of the embodiment 2 and various modified systems can also be used. For example, the electric field can also be applied by a corona discharge or a roller from a relatively high resistance belt or from the rear surface of the insulating belt in the transfer printing device.

The performance isolating type transfer belt was used in embodiment 2 because such belt operates most stably.

According to this invention, since the cleaning device has been omitted, the mechanical construction becomes simple. Accordingly, the disposition of the toner accumulating at the cleaning device and the mechanism for returning the accumulated toner to the developing device are not necessary. As a consequence, the percentage of returned toner becomes 100% so that the amount of toner that is used in vain is reduced to substantially zero.

In the prior art machine, an element that imparts a great mechanical damage to the photosensitive member was a cleaning device so that elimination thereof prolongs the useful life of the photosensitive member. Further, use of the spherical carrier enhances this advantage.

To make clear the subject matter of this invention the term electgrophotographic printer is defined as follows. In an electrophotographic printer, an electrostatic latent image is formed by projecting a light image onto the surface of a photosensitive member which has been previously sensitized to a specific polarity, for example a positive polarity, and the electrostatic latent image is devel-

oped using a toner charged with a specific polarity, for example positive polarity. Of course, theoretically a system may be considered in which the charge polarities of the photosensitive member and the toner are opposite. However it should be understood that the invention of the instant application excludes such a case.

In recent years, however, also in the field of the electrophotographic copying machine, a method has been used in which the light image of an object is electrically decomposed and thereafter reproduced as a copy with a printer. The definition of the printer defined hereinabove includes such modified method.

As above described, according to this invention the cleaning device which has been an essential element in the prior art printing machine is eliminated so that a novel method and apparatus of electrophotography can be provided wherein the developing operation and the cleaning operation can be proceeded simultaneously. In addition, it becomes possible to use extremely fine toner which was difficult to use in the prior art printer.

Claims

1. An electrophotographic printing method for use in an electrophotographic copying machine comprising:
a photosensitive member;
a charging unit for charging a surface of said photosensitive member;
a light image projecting unit for forming a latent image on the surface of said photosensitive member;
a developing unit for developing said latent image by utilizing a dry type toner and a dry type carrier;
a transfer printing unit for transfer printing a developed latent image onto a copying sheet; and
a light projecting unit for projecting light onto the surface of said photoconductive member to erase hysteresis thereof;
a charge polarity of said toner being the same as that of said charging unit;
characterized in that said method comprises the step of using a toner and a carrier both having spherical configurations so as to cause a developing operation and a cleaning operation to proceed simultaneously at said developing unit.

2. The electrophotographic printing method according to claim 1 further comprising the step of adjusting an operating timing of a transfer printing corona discharge device such that while a copying sheet is not being sent, said transfer printing corona discharge device would not operate.

3. An electrophotographic printing machine comprising:
a photosensitive member;
a charging unit for charging a surface of said photosensitive member;
a light image projecting unit for forming a latent image on the surface of said photosensitive member;
a developing unit for developing said latent image by utilizing a dry type toner, and a dry type carrier;
a transfer printing unit for transfer printing a developed latent image onto a copying sheet; and
a light projecting unit for projecting light onto the surface of said photoconductive member for erasing hysteresis thereof,
a charge polarity of said toner being the same as that of said charging unit; characterized in that both of said toner and said carrier have spherical configurations so as to cause a developing operation and a cleaning operation to proceed simultaneously at said developing unit.

4. The electrophotographic printing machine according to claim 3 which further comprises a transfer belt extending between said transfer printing unit and said developing unit for transferring said copying sheet to said developing unit through said transfer printing unit, and a corona discharge unit for applying an electric charge to said transfer belt.

5. The electrophotographic printing machine according to claim 4 wherein said transfer belt comprises an electric insulating layer and a backing layer made of an electroconductive elastic material and said electric insulating layer is charged by said corona discharge device to a polarity opposite to that of said toner whereby said toner is transferred to said copying sheet from a surface of said photosensitive member by an electric field created by a charge presenting on a surface of said transfer belt.

6. The electrophotographic printing machine according to claim 4 wherein said transfer belt is made of a relatively high resistance.

7. The electrophotographic printing machine according to claim 4 wherein said transfer belt is made of an electric insulating material, a rear surface of said transfer belt being charged by a corona discharge device.

8. The electrophotographic printing machine according to claim 3 wherein said spherical toner has a mean diameter of 1 to 7 μ.

9. The electrophotographic printing machine according to claim 3 wherein said spherical carrier has a mean diameter of 1 to 50 μ.

10. The electrophotographic printing machine according to claim 3 wherein a surface of said toner is covered by a polarizable high molecular w ight substance.

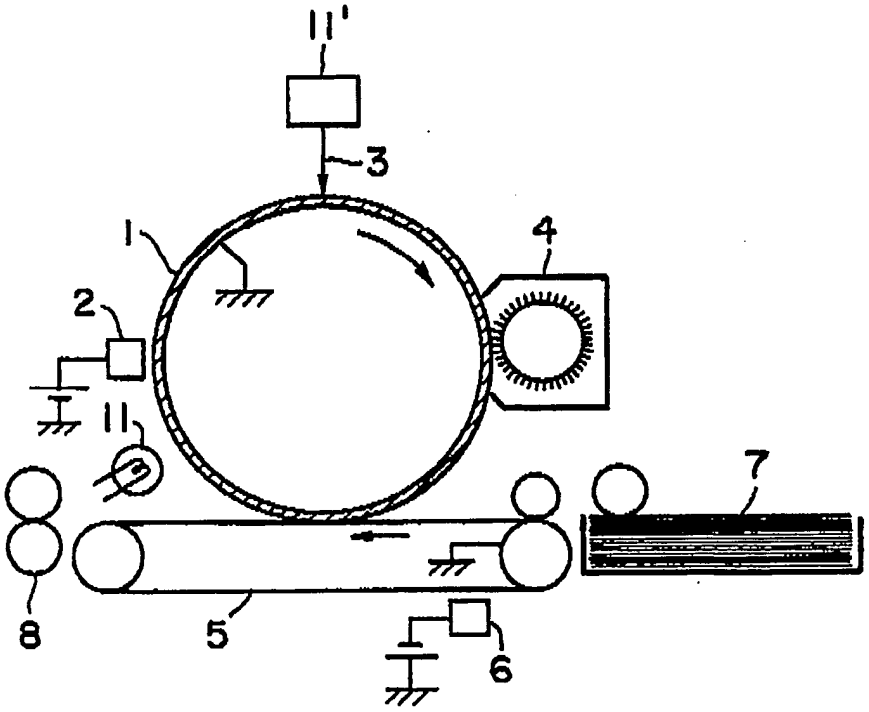

FIG. 1

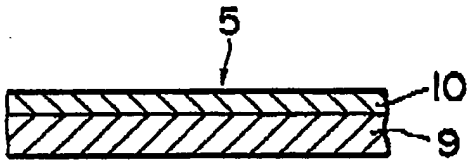

FIG. 2

European Patent Office

EUROPEAN SEARCH REPORT

Application Number

EP 89 10 9619

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (Int. Cl.4)
D,P A	PATENT ABSTRACTS OF JAPAN vol. 12, no. 390 (P-772)(3237) 18 October 1988; & JP - A - 63 133179 (TOSHIBA CORP.) 04.06.1988 (Cat. D,A)	1,3	G 03 G 15/08 G 03 G 21/00
A	PATENT ABSTRACTS OF JAPAN vol. 10, no. 68 (P-437)(2125) 18 March 1986; & JP - A - 60 207168 (CASIO KEISANKI K.K.) 18.10.1985	1,3	
A	US-A-3 628 950 (J. F. WIRLEY) * complete document *	1,3	
A	US-A-4 557 992 (S. HANEDA et al.) * claims 1-6 *	1,3,8,9	

TECHNICAL FIELDS SEARCHED (Int. Cl.4)

G 03 G 13/00
G 03 G 15/00
G 03 G 21/00

The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
BERLIN	22-08-1989	HOPPE H

CATEGORY OF CITED DOCUMENTS

X : particularly relevant if taken alone
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